HR-359 Airborne GPS

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Abstract

The airborne Global Positioning System (GPS) research project began in April 1993; a series of four tests were carried out in St. Louis, Missouri and in Ames, Iowa. All of the tests, except one, were performed in cooperation with Ashtech, a GPS firm located in Sunnyvale, California and Surdex Inc., a photogrammetric firm located in St. Louis, using Cessna aircraft, LMK 2000 cameras, and Ashtech receivers. The photo coordinates were observed using a Wild STK1 stereo comparator and were processed using Sat9, RO, Albany, and Calib softwares. The GPS data were processed using GPPS and PNAV software. The objective of this research project was to use a GPS to determine the best aerial camera location and orientation for mapping.

In the first test, the camera antenna and left wing antenna were mounted on the aircraft, which was flown over the St. Louis site. The test proved that observations can be taken using wing and camera antennas and that wing motion can be modeled to get the É rotation.

In the second test, the navigation antenna was mounted on the aircraft's fuselage. A trimble C/A code receiver was used with real-time photo mission navigation software. In a flight over the Iowa State University (ISU) campus test site, Aerial Services Inc. took photographs. This test proved that pinpoint navigation is feasible in the x-y direction and has an accuracy of ± 25 meters. Because the C/A code was used in real time, the accuracy may be about ± 50 meters in the z direction, which can be avoided by using either a P code GPS receiver or the usual on-board aneroid barometer.

In the third test, four antennas were used: camera, left wing, right wing, and tail. In this test flight over the St. Louis site, two GPS LI/L2 P12 receivers and one 3DF GPS receiver were used. The test proved that the tail antenna is not suitable due to multipath, that the 3DF GPS receiver is not suitable for airborne GPS applications because it is an Ll GPS receiver, and that at least seven satellites are needed for reliable PNAV solutions.

In the final test, one navigation antenna; four airborne GPS antennas: camera, left wing,

right wing, and forward; four Z12 receivers on-board; and two Z12 receivers on the reference stations were used. This test confirmed that (1) photo coordinates have to be observed two or times to eliminate small errors, (2) ground elevations established by GPS may have ± 10 centimeters errors because of local geoid undulation, (3) the photographic site has to be within 10 kilometers of the reference base station, (4) the camera antenna coordinates have to be corrected for geoid undulation, and (5) the accuracy of the Z12 is 0.2 millimeters, which neglects the multipath, resulting in the accuracy of ± 0.0001 radians or better in the É angle.

In summary, the project showed that airborne GPS is feasible for aerial camera location and orientation. In block triangulation, no ground control is required if the site is within 10 kilometers of the reference base station. In a strip, a self calibration is required to transform $É_G$ to $É_p$ and the calibration site is within 10 kilometers of the photographic site or the height differences between two or more ground control points in the direction perpendicular to the flight are known.

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